AN APPARATUS FOR THE DETERMINATION OF CARBON DIOXIDE PRODUCTION IN PHYSIOLOGICAL PLANT STUDIES

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From time to time, physiologists have proposed various methods for determining the amount of carbon dioxide evolved in physiological plant studies. These methods vary greatly in the apparatus used, conditions to which they are applicable, and degree of accuracy obtainable.

In the course of investigating the respiratory rate of plants in water culture, a large number of the published methods and apparatus was tested. It was found that liquid absorbents gave incomplete absorption unless the apparatus allowed the bubble to be broken at least three times during its passage through the liquid. In order to accomplish this, it was necessary to use an amount of absorbent which rendered the titration of small differences inaccurate, or to use special units of absorptive apparatus from which the absorbent could only inconveniently be completely removed for each titration.

In view of the inconvenience of using liquid absorbents the present apparatus was designed and it has proved so satisfactory that it was thought to be worthy of being brought to the attention of other workers. The general plan is an adaptation of the widely used method for determining carbon by combustion. The thorough absorption of carbon dioxide has been amply verified by many analysts.

The bell jar *H* is of any convenient size and rests on the glass plate *I*, the contact with which is sealed air tight with vaseline. Air enters the chamber through the large test-tube *D* (32 x 200 mm.) which is filled with soda lime or Ascarite, and is withdrawn through the larger test-tube *J* (38 x 300 mm.) which contains concentrated sulphuric acid. The Folin ammonia tube *K* is especially efficient in breaking up the air bubbles, insuring a more complete drying of the air stream. Tube *L* is of small size and contains phosphorous pentoxide. The absorption bulb

found most convenient was the Fleming or Fleming-Martin type and is designated *P*. The lower chamber contains Ascarite, and the upper, phosphorous pentoxide. The small test-tube *R* also contains phosphorous pentoxide. The air passes out through the suction line *E*. Tower *B* contains calcium chloride, and the jar *A* serves as a safety chamber to prevent water from entering the apparatus through the water pump which attaches to it. The

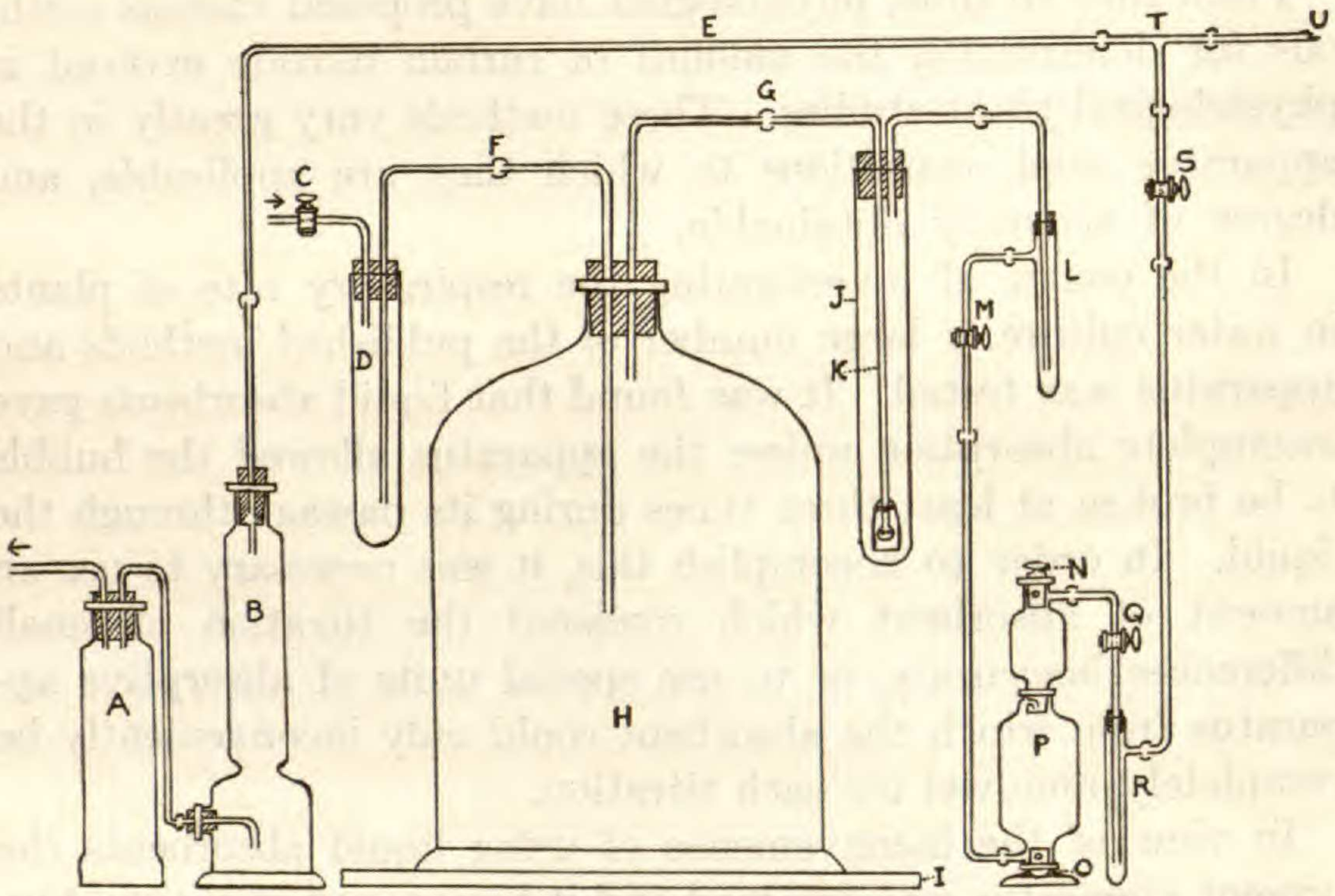

Figure 1

T-tube, *T*, allows several similar units to be operated simultaneously on the same suction line. The tubes *D*, *J*, *L*, and *R* are held in position by clamps.

In carrying out the determination, the rubber tube-connections *F* and *G* are disconnected, which enables the object of study to be placed beneath the bell jar. Stopcock *S* is then closed, and the suction turned on. By slowly opening *S* and counting the bubbles passing through the sulphuric acid tube *J*, the rate of flow may be controlled. The stopcock *S* is used to control the rate of flow rather than *M* or *Q*, because it can be adjusted and not altered. Stopcock *C* is closed when the apparatus is not in use.

Before disconnecting the Fleming bulb for weighing, stopcocks *M* and *Q* are closed to protect the phosphorous pentoxide in tubes *L* and *R* from contact with the atmosphere. The Fleming bulb is itself sealed by turning the top *N* and the base *O*. It is then disconnected and weighed on the analytical balance.

Owing to the impossibility of controlling accurately the temperature of the respiration chamber, for comparative results several units must be run simultaneously. Five units have been found to work very satisfactorily, attached to a single suction line.

The use of Ascarite as the carbon-dioxide absorbent is to be preferred over soda-lime, since its change in color as the carbon dioxide is absorbed indicates when renewal is necessary. A large number of determinations may be made with a single charge.

The drying agent must be more efficient than concentrated sulphuric acid and must be inserted in both sides of the Fleming bulb to establish proper equilibrium. Either phosphorous pentoxide or "Hydralo" (Al_2O_3) is satisfactory. In any case, a plug of glass wool should be inserted above it to prevent the air current from carrying away dust-like particles.

The accuracy of the determination is limited by the amount of carbon dioxide in the apparatus at the beginning and by the sensitivity of the balance used in weighing. The filled Fleming tube weighs about 150 grams, but this weight allows a balance sensitivity sufficiently great for most experiments.

A greater degree of accuracy may be obtained in weighing the Fleming bulb if it is allowed to stand on the balance twenty minutes, and the base opened and quickly closed before its weight is determined. A similar but unfilled bulb on the pan with the weights reduces the error involved by the presence of different amounts of moisture adsorbed on the surface at different times of the day.

The above-described apparatus is particularly adapted for measuring the carbon dioxide output of fruits, soils, and plants in water culture. In the latter case, the nutrient solution should be renewed just before the determination is made in order to reduce the possibility of introducing an error by the activity of micro-organisms.